requiring the use of a 22 millimeters diameter tube as the pressure drop within such a tube is negligible but the use of a smaller tube will not guarantee the pressure regulation within acceptable bounds.

In the case of two levels of pressure apparatus, as changing the blower speed within a breath is impossible to achieve due to the high inertia, the highest level is delivered by the blower and the lowest is managed by using pneumatic valves, pressure dividers or alternative methods.

The size of the impeller, the sensor positioning and attachments and the number of wires required increase the size of the blower and thus of the apparatus. Furthermore the precise positioning of the sensors complicates the assembling of the motor implying an increase of the cost.

Summary of the invention

The invention object is to provide an apparatus able to deliver air to a patient at a controlled pressure in such a way that the pressure could be modulated within a breath according to the breath pattern and according to events detected from the patient .

Another object is to provide an apparatus enabling the use of smaller diameter tubes than the standard 22mm.

Another object of the invention is to provide an apparatus with a lower size, being more power efficient and to improve comfort, to be as quiet as possible.

A further object is to provide an apparatus easier and cheaper to assemble.

The subject of the invention is an apparatus able to deliver air to a patient at a controlled pressure in such a way that the pressure could be modulated within a breath according to the breath pattern and according to events detected from the patient .

This is obtained by a very efficient centrifugal blower which is able to rotate at high speed (up to 50000 round per minute) and to decelerate and accelerate very quickly(±10 hPa

CLAIMS

1. An apparatus (1) to assist a patient respiration by delivering air to this patient trough a mask, comprising an air blower (33) wherein the impeller (5) is rotated by an electro motor comprising a rotor (3) and a stator (8), said stator having at least three sectors (8a, 8b and 8c), the rotation of the rotor being enabled by changes of the polarity of the sectors, each sectors polarity configuration constituting one step of the rotor's rotation, said apparatus comprising a driving unit (36) changing the sectors polarity when the rotor is at his optimal position, so that the efficiency of the electro motor enables the blower to have fast accelerations and decelerations within one patient's breath step, said breath step consisting of one inspiration and one expiration.

2. The apparatus (1) according to claim 1, wherein said driving unit (36) comprises means to sense the back electro motor force generated by the electro motor, and thus changing the sectors (8a, 8b and 8c) polarity configuration when the back electro motor force reaches the zero value.

3. The apparatus (1) according to claim 2, wherein said stator (8) has at least three sectors (8a, 8b and 8c), each of said sectors being connected to one switch (HA, HB, or HC) connected to the positive plot of the power supply and each of said sectors being connected to one switch (LA, LB or LC) connected to the negative plot of the power supply, in order that one of the rotor's rotation step is obtained when said driving unit (36) applies the tension to the stator by connecting the first sector (8a) to said positive plot, connecting the second sector (8b) to the negative plot and setting the third sector (8c) not connected to a power supply plot, thus enabling to measure the back electro motor force of the motor between the third sector and the negative plot, said driving unit changing the sectors polarity configuration when the back electro motor force reaches the zero value.

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4. The apparatus (1) according to claim 3, wherein said tension applied is a Pulse Width Modulation, the driving unit connecting one of said stator sectors (8a, 8b or 8c) to the positive plot during a first duration of time and then, and then, during a second period, disconnecting the same sector from the positive plot and connecting it to the negative plot, so that in case of deceleration of the motor the generated current is sent to the negative plot, thus providing a fast deceleration of the impeller (5).

5. The apparatus (1) according to claim 3 or 4, wherein said stator (8) is a three sectors stator and said rotor is a dipole magnet, said stator thus having six sectors polarity configuration so that the rotor performs one 360° rotation in six rotation steps.

6. The apparatus according to any one of claims 2 to 5, wherein said stator (8) is a toroïdal stator and wherein each of said sectors (8a, 8b or 8c) are coils connected with only one wire.

7. The apparatus according to any one of the previous claims 2 to 6, wherein when the blower (33) is functioning and no back electro motor force is measured, said driving unit (36) fixes the tension applied and changes the sectors (8a, 8b and 8c) polarity configuration after a given time, said driving unit decreasing this given time every step until a back electro motor is detected and then applying the required tension and changing the sectors polarity configuration according to the back electro motor value.

8. The apparatus according to any one of the previous claims, further comprising bearings (4a and 4b) and a bearing holder (93), and wherein said impeller (5), said rotor (3) and the shaft (91) of said impeller are fixed together, said inner ring of the bearings being fixed to said shaft and the outer rings of said bearings being hold by the bearing holder, which is fixed in the apparatus, and said rotor being shifted outside the stator, preferentially at an equal distance of each of the three stator sectors (8a, 8b and 8c), so that the

stator also generates on the rotor an axial force oriented along said shaft, thus generating a preload on the bearings.

9. The apparatus according to any one of the previous claims, further comprising a power supply manager (29) connected to the power supply source (30 or 31), said power supply manager comprising a current sensor (55), a comparator (53), a load resistor (54) and a mean to switch on the load resistor between the positive power supply and the ground when the current measured by said current sensor is negative, in order to dissipate this current in said load resistor by thermal effect.

10. The apparatus according to any of the precedent claims, being designed to be connected to a tube of a diameter less than 22 millimeters, a first extremity of the tube being connected to the air outlet of the blower (33) and a second extremity of the tube being connected to a mask in which the patient breaths.

11. The apparatus according to any of the precedent claims further comprising :

- at least one means (110) for detecting the patient's breathing parameters,
- a pressure control unit (37) to adjust the pressure delivered by said blower at the level of said mask, and comprising an estimation module (100) connected to the means for detecting the patient's breathing parameters, in order that the estimation module is able to determine when the patient is inspiring or expiring and in response the pressure to apply to the patient's mask, during inspiration and during expiration.

12. The apparatus according to claim 11, wherein said at least one means detects the patient's airflow and send it to a breath estimator (132) which determines the airflow as a function of time and transmit this function to said estimation module (100) which will thus estimate the pressure to apply to patient's mask according to the airflow function, in order to decrease the effort of the patient's lung while maintaining, during one breath step, the average value of the

pressure at the mask P_M equal to the pressure of treatment, the estimation module (100) preferentially determining the pressure P_M at the mask as a function of time.

13. The apparatus according to claim 11 or 12, wherein the control unit comprises a non volatile memory in which the clinician can enter clinical settings (120) comprising at least the treatment pressure and possibly the pressure to apply according to the patient's breathing parameters, said estimation module providing the pressure PM according to these clinical settings and to the patient's breathing parameters.

14. The apparatus according to claim 13, wherein the patient can enter patient settings (122) in said non volatile memory, said estimation module (100) providing the pressure according to these patient settings and to the patient's breathing parameters within bounds given by the clinician settings (120).

15. The apparatus according to any one of claim 11 to 14, in which the estimation module (100) is able to determine that an event (E_1, E_2 or E_3) occurs in patient's breathing thus enabling said pressure control unit (37) to provide the blower (33) with the tension to apply to adjust the pressure at patient's mask.

16. The apparatus according to any one of claim 11 to 15, wherein said means (22 and 23) for detecting the patient's breathing parameters enable the pressure control unit (2) to compute the airflow at patient's mask, said estimation module (100) determining that an event (E_1, E_2 or E_3) is occurring with the airflow parameters or shape.

17. The apparatus according to claim 11 to 17, wherein said estimation module (100) has an inspiration output (102) where said estimation module set the mask pressure PM value during inspiration, and wherein said estimation module has an expiration out put (104) where said estimation module set the mask pressure PM value during expiration, said pressure control unit (37) comprising a switch (108) which is connected alternatively to the inspiration output or expiration output according to patient's breathing.

18. The apparatus according to claim 11 to 17, wherein the means for detecting the patient's breathing parameters comprise a pressure sensor (23) for sensing the pressure at said first tube extremity and one pressure sensor (22) for sensing the pressure at the extremity of the tube connected to the blower outlet, said airflow computation module being able to calculate the airflow from these pressures and from the tube airflow resistance coefficient KT.

19. The apparatus according to claim 11 to 18, wherein the apparatus further comprises a starting mean which, when actuated, orders the estimation module (100) to detect a breathing activity, said estimator module sending the instruction to stop the blower (33) if no activity is sensed after a given delay.

20. The apparatus according to any one of the previous claims, wherein a power supply manager (29) comprise a communication module (65) which transmits the data trough the power source wires.

21. The apparatus according to any one of the previous claims, said communication module (65) comprises a Frequency Shift Keying (FSK) modulator (50) which transforms the binary data send by the apparatus sensors or elements in a modulation of the frequency of the tension applied on a voltage controlled current source (52), connected to the external power supply, so that the voltage controlled current source transmits the modulation corresponding to the data, a FSK demodulator converting the voltage frequency modulation into binary data (61) and transmits it to the elements, so that each sensor or module connected to the power source is able to receive or transmit information.

22. The apparatus according to any of the previous claims, further comprising a phonic insulation box (34) wherein the blower (33) is placed, said impeller (5) having a size less than 60 mm and comprising between 15 and 45 blades, preferentially 27, so that the impeller rotates at a speed that generates a sound at a high frequency, enabling said box to insulate the patient from this noise.

23. The apparatus according any one of the previous claims, said apparatus being used for the treatment of breathing anomalies, such as snoring, apneas, or hypopneas.

24. The apparatus according to claim 6 and any of claims 7 to 23, wherein said stator (8) is obtained by a strip wound cores technique with a high grade thin silicon steel, of about 0.05 mm thickness.